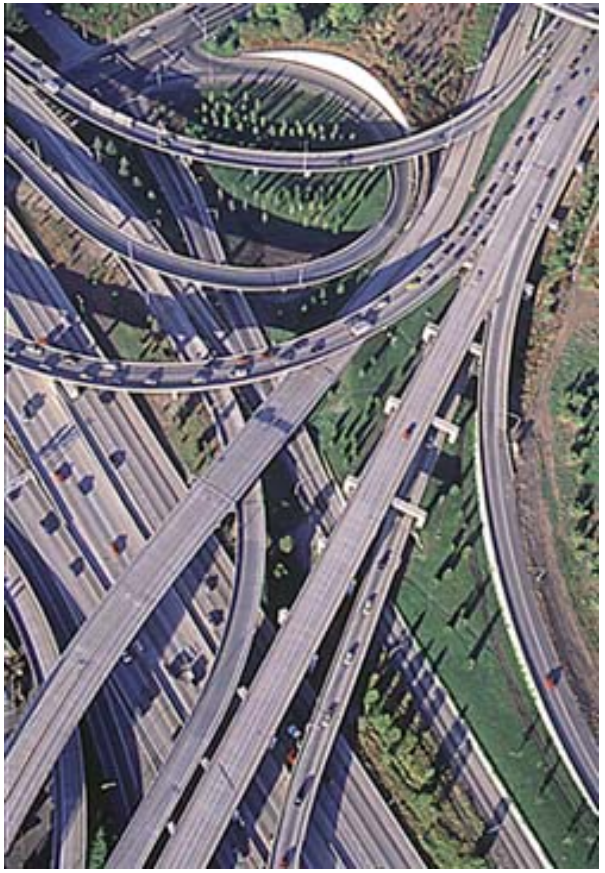
Impact of Galileo on the road sector

Towards guaranteed integrity



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- Context
- ITS Services
- Classification of ITS services
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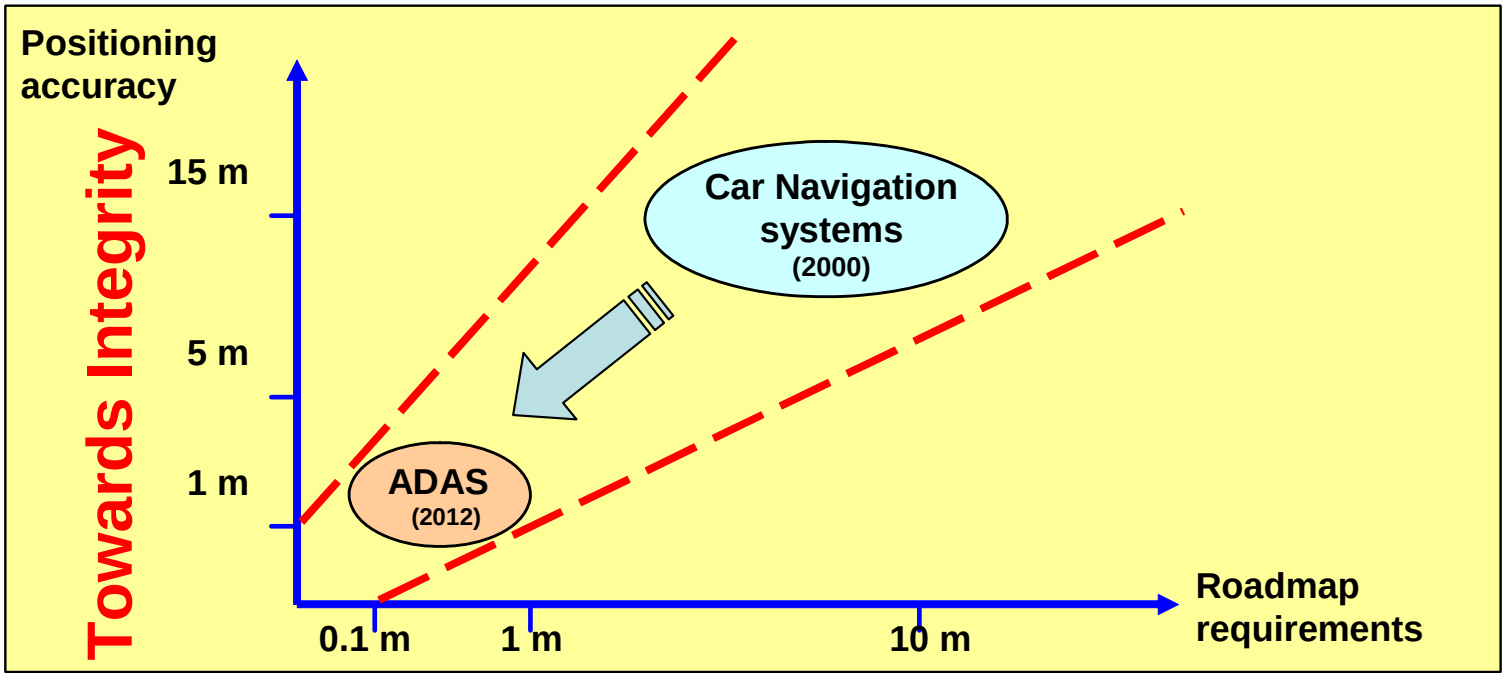
Context

- Road Safety and ITS applications
  - European transport policy
  - Reduction of road fatalities by 2010
  - Improvement of road infrastructure, safer cars
- Initiatives
  - Include new developments of the information society technologies (IST) **> TELECOM**
  - Interaction between the driver, the vehicle and the road environment **> NAVIGATION, Galileo**
  - Development of advanced road databases

➲ **Development of Intelligent Integrated Transport Safety Systems**

Context

- Deployment of transport safety system
  - Evolution of GNSS and digital map databases
  - Development of ITS and Advanced Driver Assistance Systems (ADAS)



Towards Certification

Context

- New driver assistance system-ADAS
  - BMW Group is developing a dynamic road prediction system (DPP) for safe overtaking
  - The ADAS is combing digital map data, GPS position and velocity and acceleration from the car's system
  - This ADAS enhance safety and support drivers actively without interfering
  - **DPP is based on available GPS and common map databases designed for ADAS**

ITS Services

- **ISO 14813-1: Intelligent transport systems (ITS) –** Reference model architecture for the ITS sector – Part 1: **ITS service domains**, service groups and services

- **Main ITS service domains**
  - Traveller information
  - Traffic management and operations
  - Driver assistance and vehicle control
  - Freigth transport
  - Public transport
  - Emergency
  - Transport-related electronic paymant
  - Road transport-related personal safety
  - …

ITS Services

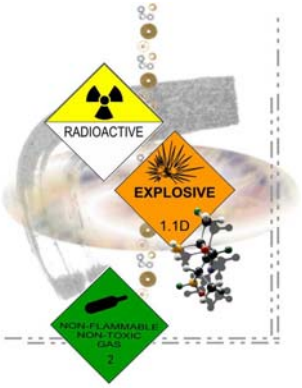
Role of the positioning in the main ITS services

- Traveller information
  - Pre-trip information
  - On-trip driver information
  - Route guidance and navigation

- Traffic management
  - Transportation planning support
  - Policing/enforcing traffic regulation

ITS Services

- Driver assistance and vehicle control
  - Vision enhancement
  - Automated vehicle operation
  - Collision avoidance
  - Safety readyness
- Freigth and fleet management
  - Commercial fleet management
  - Management of dangerous goods



ITS Services

- Public transport
  - Public transport management
  - Shared transport management
- Emergency
  - Emergency notification and personal security
  - Emergency vehicle management
- Electronic financial transactions
- Safety

Classification of ITS services

- Positioning plays a key role in several ITS services
  - What is the level of performance required ?
  - What are the main characteristics of the positioning performance ?
- Classification may be based on various criteria
- **Issue**
  - **What is the impact of a misleading information?**
  - **What is the acceptable level of risk ?**
  - **What kind of implications: legal, commercial, liability, Safety of life,… ?**

Classification of ITS services

- Classification proposed within the Giroads (www.intelligentroads.org) project:
  - **Safety-of-life**: all applications considered as safety critical, or having any safety implication
  - **Liability-critical**: all applications presenting any commercial or legal relationship between the provider of service and the final users
  - **Non-safety-of-life**: all applications not presenting any commercial, legal or safety implication

Classification of ITS services

- Examples of applications:
  - **Safety-of-life**: emergency services, ADAS, ...
  - **Liability-critical**: electronic fee collection and road pricing, legal speed enforcement,…
  - **Non-safety-of-life**: navigation and in-car information, fleet management,…

The main differentiator among this classification is the **integrity requirement at the user level**

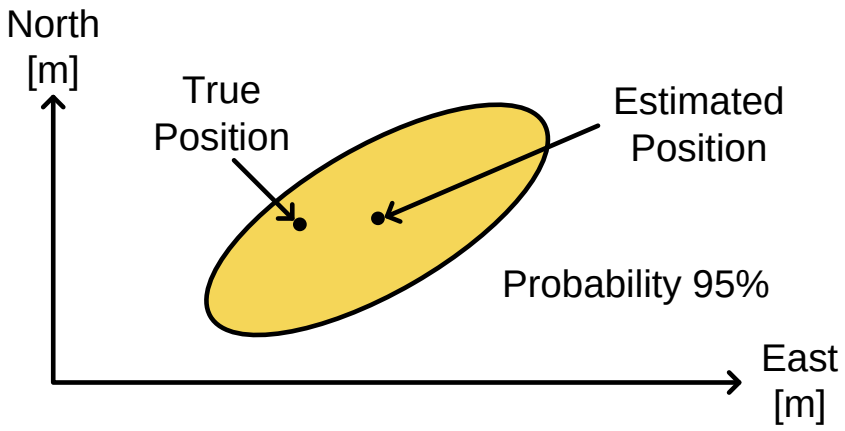
Performance of positioning systems

Main features used for the evaluation of the performance

- **Position accuracy**
  - **Predictable accuracy**: accuracy of a position with respect to the charted position (true)
  - **Relative accuracy**: accuracy of a position relative to another user or to a road feature
- **Coverage**: area (region, cordon, specific point) where the performance of the system is adequate
- **Integrity:** ability of the system to provide timely warnings to the users when the system should not be used
- **Availability**: ability of the system to determine a position with the required accuracy at any time and any location in the coverage area
- **Continuity**: ability of the system to perform its function without interruption during the intended operation
- **Update (Fix) rate :** number of independant position provided by the system during a time interval
- **Time to first fix** :time interval until the system output a position

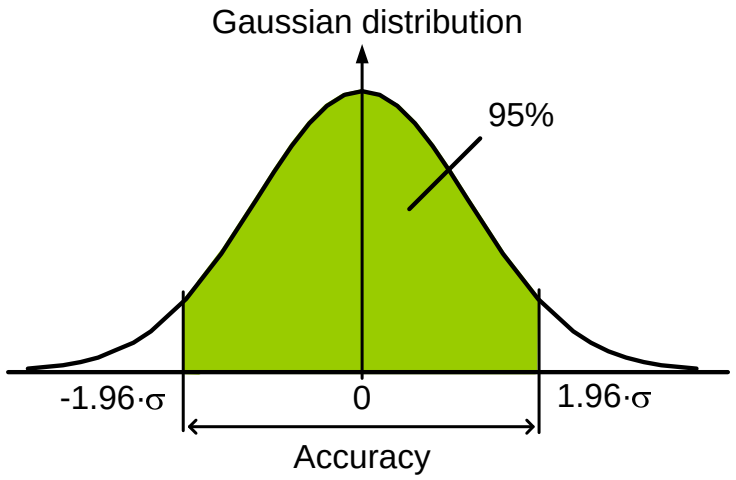
Performance of positioning systems

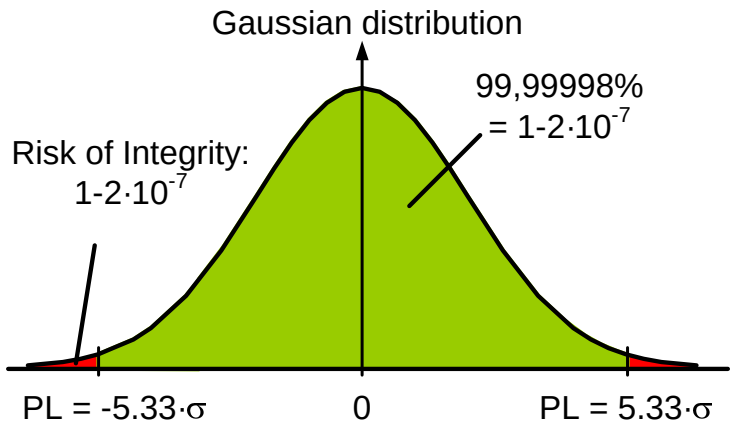
- Accuracy
  - Horizontal
  - Estimated global position & error (ellipse)
    - Level of probability
  - True position included or not



Performance of positioning systems

- Integrity Concept
  - Ability of a system to timely provide valid warnings to the users
- Risk of Integrity
  - Probability of providing a signal that is out of tolerance without warning the user
  - PL : Protection Level Statistical error bounds

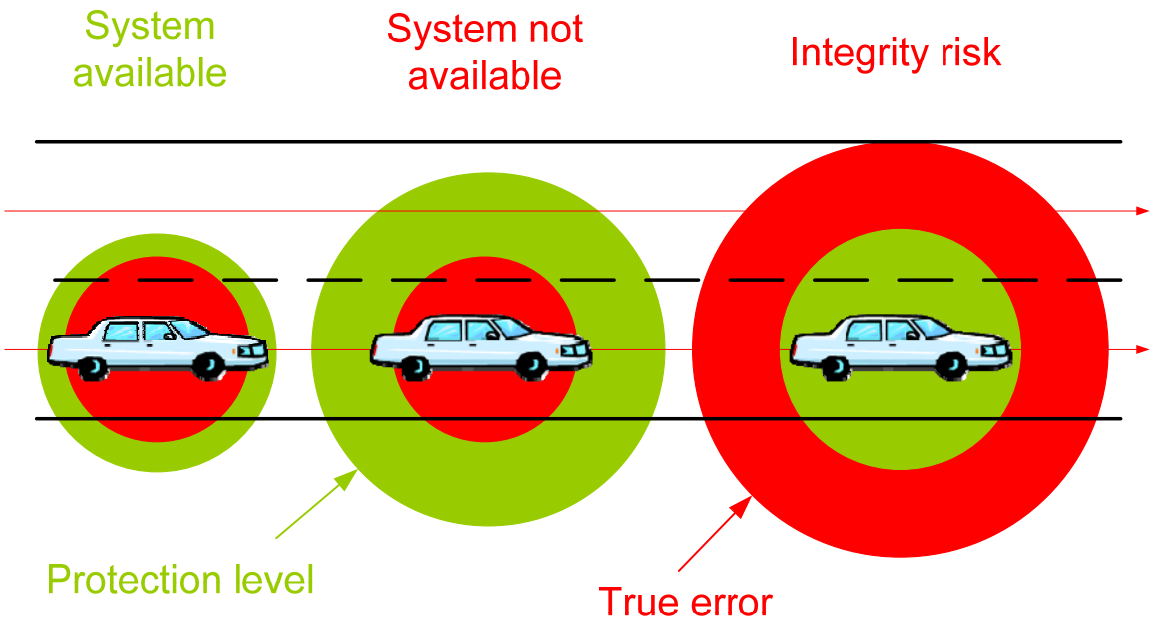




Performance of positioning systems

- Available: True error < Protection level < Alert Limit
- Not available: True error < Protection level **>** Alert Limit

- **Integrity Risk: True error > Protection Level**

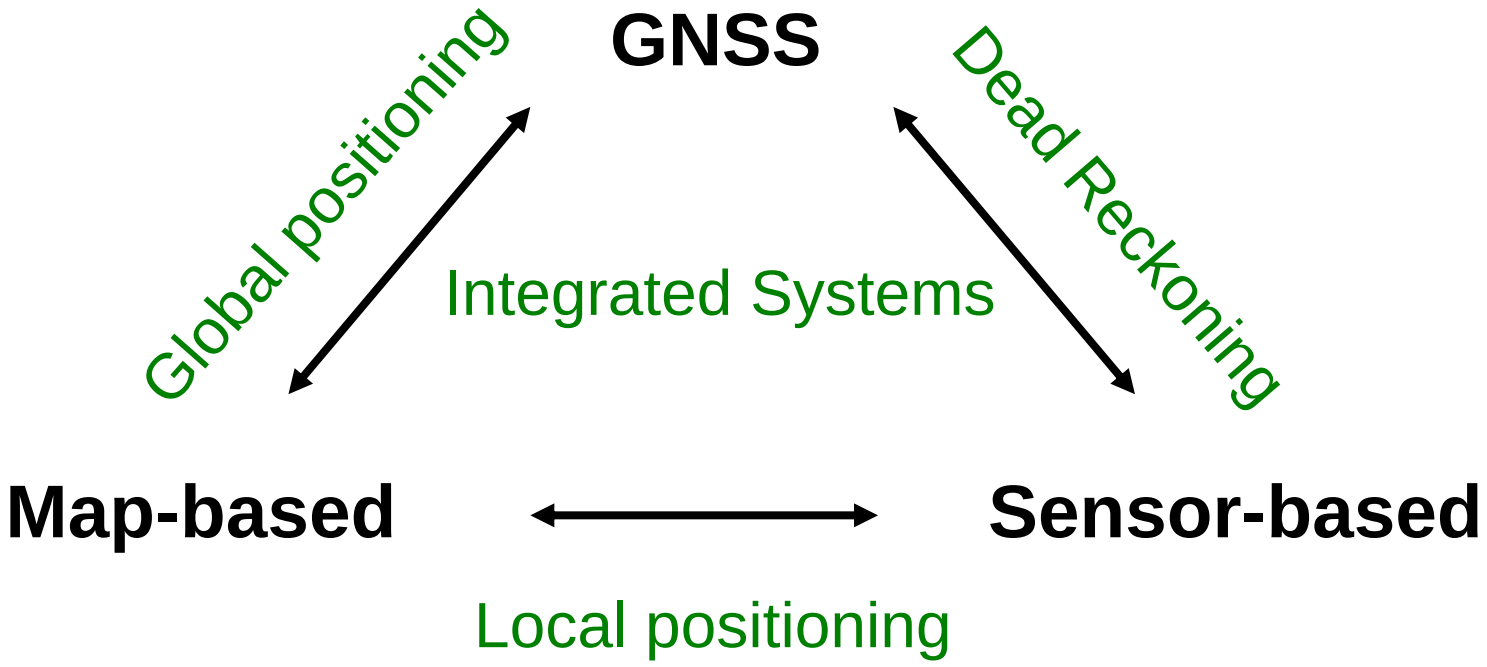


AL:Alert Limit depend on the application

Types of Positioning Systems

- **GNSS-based**: satellite-based positioning, provide a 3D position (lat., long., altitude) in a global reference system (WGS84)
- **Sensor-based**: provide a geometric information (distance, angle) relative to a fix or to specific road features in a local reference system
- **Map-based**: provide positioning relative to a map feature in a mapping reference system

Types of Positioning Systems



- Most of ITS applications are based on global/local positioning and are linked to onboard digital maps

Types of Positioning Systems

- **GNSS/Sensor-based** : enhanced positioning system with better availability and continuity based on an integrated system and a dead reckoning (DR) method
- **GNSS/Sensor & Map-based** : integrated positioning systems requiring map information
  (don't run without map information)

ITS applications require to combine all types of positioning concepts

Services and Certification

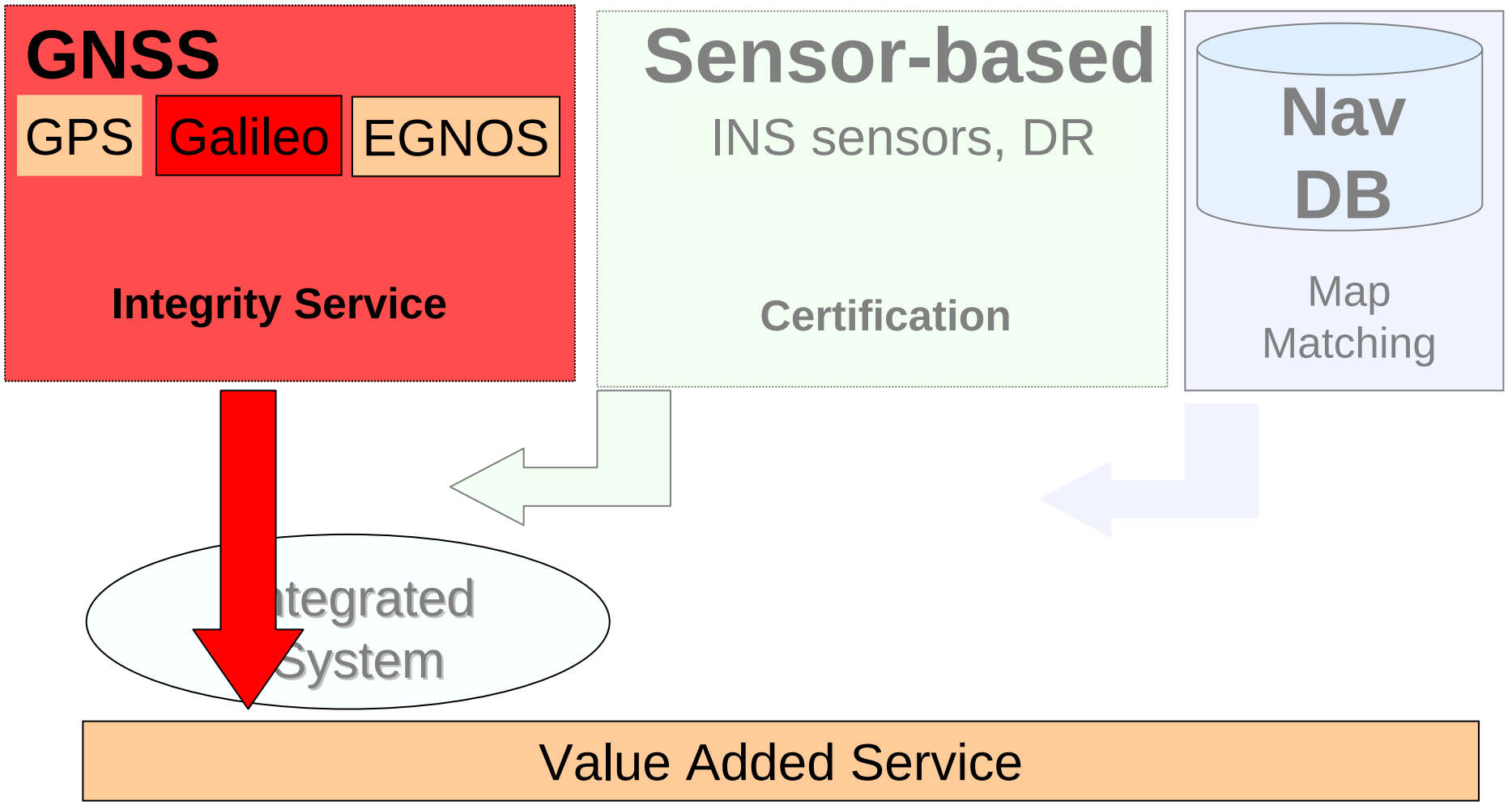
- **GNSS/Galileo** : Navigation services
  Commercial, Safety of Life
  - Improved accuracy and better availability
  - Integrity of the navigation signal (in space)
  - Certification and service guarantees
    - Provided by the Galileo operator
  - Possibility to implement value-added services
    - Provided by a local operator

  Issue

  Appropriate for « open-sky » area (controlled environment)

  - What kind of services should be proposed for challenging areas (non-controlled) ?
    (Urban canyon, forested & mountainous areas)

  - How to provide guaranteed integrity at the user level ?



Galileo-only Terminal of navigation with integrity service at the user level

ITS Service : Example

- Road charging
  - Use of GNSS: identify whether and when the vehicle is within a specific area
  - When applied to road charging, the provision of guaranteed integrity translates directly into the availability to charge for the service
  - In addition to the GNSS integrity service, robust algorithms have to be implemented at the user level (value added service)

Ref: project ADvantis, GMV SA

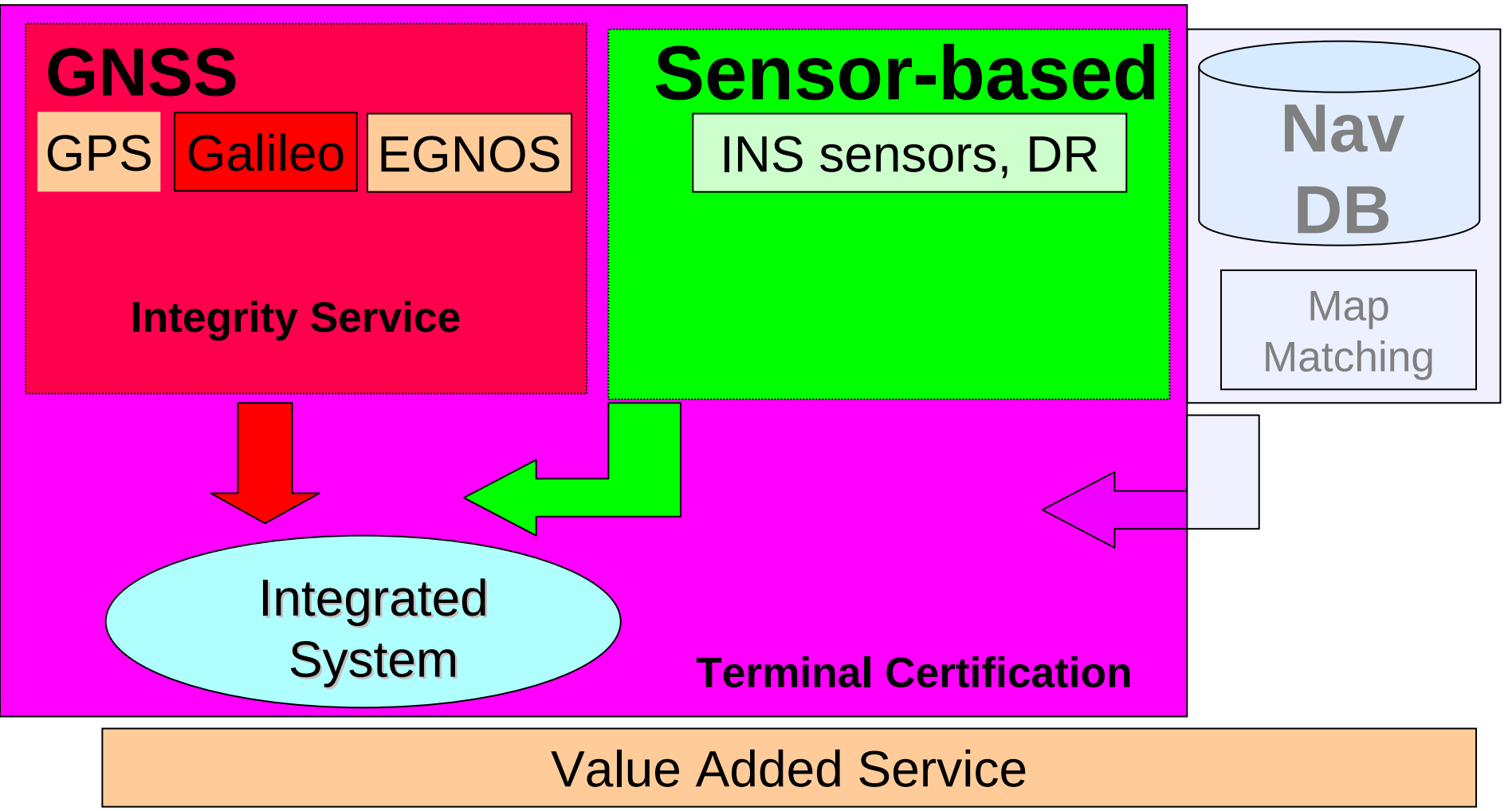
Services and Certification

- **Galileo/Sensor-based** : Terminal of Navigation with integrated services
  - Improved accuracy and update rate
  - Better availability and continuity
  - Integrity monitoring
    - Combine Galileo services with dynamic sensors information
    - Provide Integrity monitoring at the user level
  - Possibility to implement value-added services
    - Provided by a local operator

Issue

Better performance in uncontrolled environments (urban area, forested & mountainous areas)

Towards terminal certification



Galileo/Sensor-based Terminal of navigation with integrity service at the user level

Services and Certification

- **Digital Maps (Nav DB)**
  - On board digital maps can be seen as a special sensor for road safety system
  - Digital maps will provide safety relevant information
  - Types of maps: (ref.: Project Maps & ADAS, FP6)
    - Prediction along the road
    - Provision of context information
    - Acting as an intelligent filter
    - Acting as a spatial memory

Issue

To define a standard interface for ADAS and ITS applications

To make safety related data available

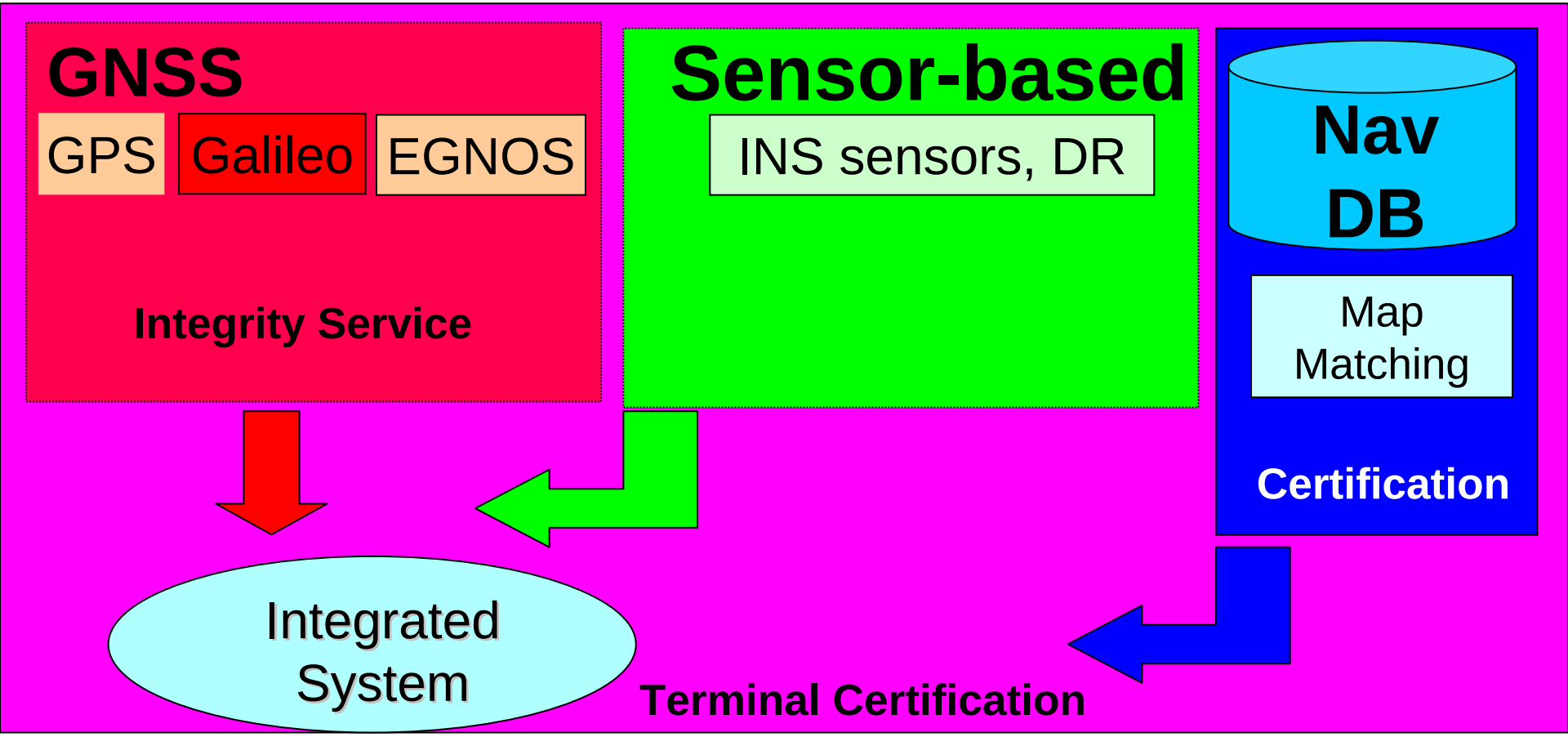
What about the certification of navigation data ?

Services and Certification

- **Galileo/Sensor & Map-based** : Terminal of Navigation with integrated services and link with a map database
  - Improved accuracy and comparison with road features
  - Better availability and continuity
  - Integrity monitoring
    - Combine Galileo services with mapping information (Nav DB)
    - Matching of GNSS information with road features
  - Possibility to implement value-added services
    - Provided by a local operator

Issue

Cooperation of multiple providers (GNSS, maps,…)
How to guarantee a combined service (GNSS/Sensor + Nav DB) ?



Value Added Service

Terminal of navigation with integrity service at the user level

ADAS: Example

Lane departure warning

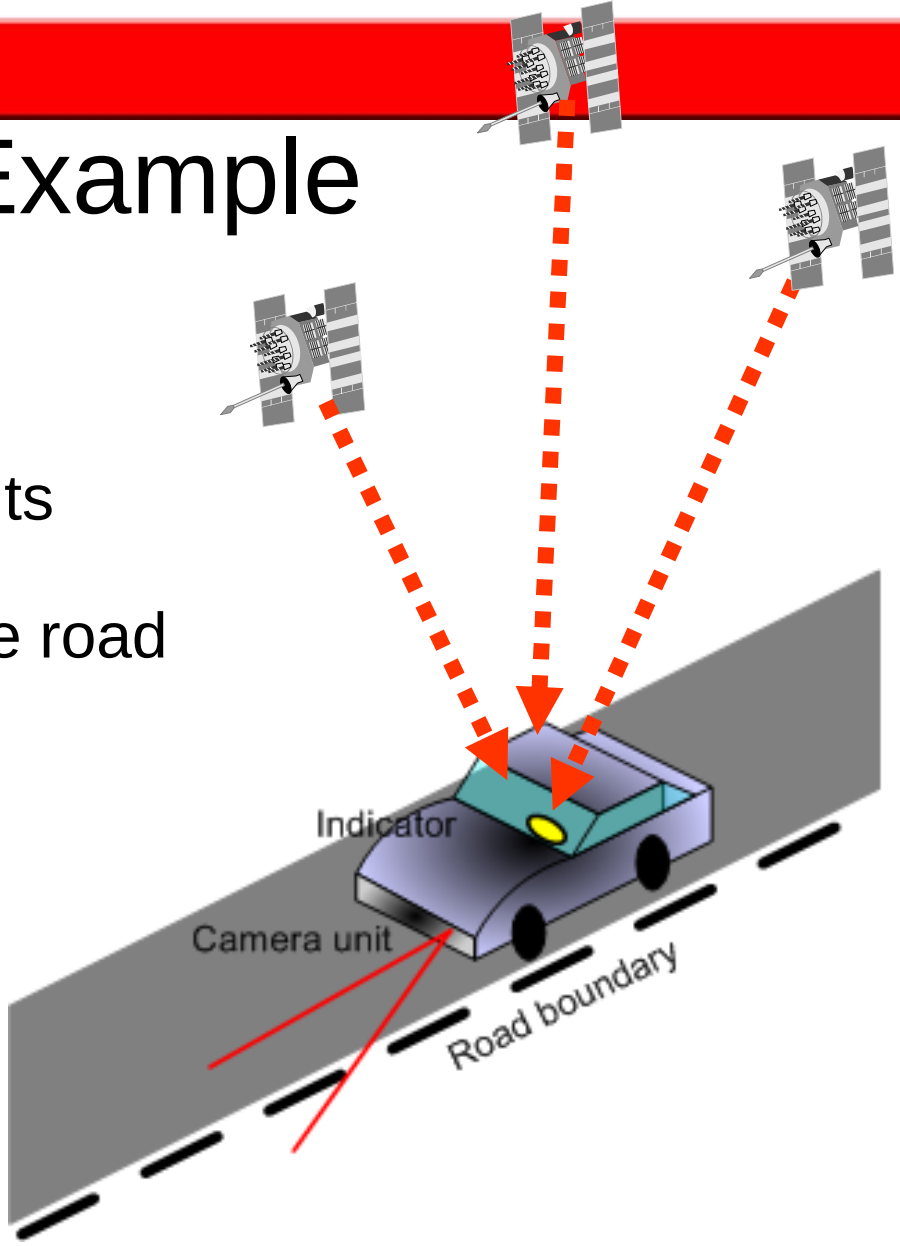
- ADAS: Lateral control
  - Positioning the vehicle on its lane
  - Tracking the marking of the road

Local positioning

  - Close range sensors (radar, CCD)
    - Tracking road features
    - High frequency

Global positioning

  - GNSS-based positioning
    - Low frequency
    - Combined with road geometry



Conclusions

- **Why Galileo in ITS Services ?**
  - GNSS positioning in a global reference system became necessary in many applications linked with digital maps
  - Safety of life and liability-critical applications require a high level guarantee of integrity at the user level
  - Galileo will not cover all the links in the integrity chain (from space to the user)
  - The development of value-added services is absolutely necessary for the implementation of integrity services at the user level

Summary

- ITS and especially ADAS applications will increase the interaction between the driver, the vehicle and their environment
  - This interaction is only possible with high performance navigation systems and high quality digital maps
- The reliability of ITS applications is based on integrated solutions
  - Extended map database with safety relevant information
  - Combined positioning systems : GNSS/Galileo & positioning sensors
- Integrity play a key role in the implementation of liability-critical and safety of life applications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